CERES/ARM Validation Experiment (CAVE)

David A. Rutan(1), Fred G. Rose(1), Natividad Smith(1), and Thomas P. Charlock(2)

1. Analytical Services & Materials Inc., Hampton, VA
2. NASA Langley Research Center, Atmospheric Sciences Competency, Hampton, VA

CERES/SARB

The Clouds and the Earth's Radiant Energy System (CERES), scanning radiometers flying on TRMM, TERRA, and AQUA(12/2001) currently supplies TOA broad-band 'footprint' fluxes and gridded, time/space averaged, data products. The Surface and Atmospheric Radiation Budget (SARB) group will provide model fluxes for the TOA, surface, 500mb, 200mb, 70mb, and 1.0mb for every CERES footprint. The first publicly available SARB data product (a Beta1 product not suitable for publication) can be retrieved from the NASA Langley Research Center Atmospheric Sciences Data Center at: http://eosweb.larc.nasa.gov/.

Data Source & Availability

- Atmospheric Measurement Program (ARM/DOE)
- SURFRAD (NOAA Air Resources Laboratory)
- Climate Monitoring and Diagnostic Laboratory (NOAA)
- Baseline Surface Radiation Network (BSRN)
- National Renewable Energy Laboratory (NREL/DOE)
- CERES Ocean Validation Experiment (COVE/NASA LaRC)
- Indian Ocean Experiment (INDOEX) Univ. CA, San Diego
- AEROsol NETwork (AERONET/NASA Goddard)
- ASRC Solar Group (SUNY Albany)

Data Visualization

An important aspect of the CAVE data base is the ability to quickly visualize/summmarize the data. To facilitate this three web-based tools are made available for graphically visualizing the primary data files. Shown below are the outputs from each of these tools.

Water Vapor Profiles

- Currently CAVE data base provides limited atmospheric profile data at the ARM SGP for 1998.
- Water vapor is observed redundently at the ARM/Central Facility by:
  - Balloon borne radiosonde data launched nominally 3 times daily, 5 days a week.
  - ARM Raman Lidar (R/L)
  - Microwave Radiometer (MWR)
  - Surface based LW FTS spectrometer (AERI), combined with GOES LW sounder AERI/GOES (A/G).
- A comparison of water vapor retrieval at the ARM/SGP is shown below for Jul-Oct 1998.
  - Sondes launched nominally 3 times daily, 5 days a week, then interpolated in time to 1/2 hour.
  - R/L and A/G profiles have high temporal resolution
  - At night under clear skies the R/L "sees" quite high, R/L does not see much above 500mb during the day.
  - Neither A/G nor R/L penetrates thick cloud.

The CAVE

NASA's Clouds and the Earths Radiant Energy System (CERES) experiment calculates flux profiles for instantaneous footprint data.

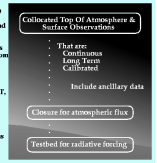
Validation of model Top of Atmosphere (TOA) and surface fluxes is required.

CERES ARM Validation Experiment (CAVE) builds a data base of collocated TOA flux observations from the CERES instruments and surface flux observations.

CAVE provides, 1998 onward, near continuous surface observations of radiometric fluxes, from established programs: ARM, SURFRAD, CMDL, NREL, LaRC, BSRN, INDOEX.

CAVE provides, where available, additional data such as aerosol optical depth (AERONET, CMDL, SUNY ASRC) and meteorological observations.

CAVE provides, when possible, cloud fraction (primarily from the Long/Ackerman PSP algorithm) and diffuse shortwave observations adjusted for the night–time offset of the instruments.



SAM Files

Surface Flux | Aerosols | Meteorology

All Files:
- SW Direct Normal
- SW Diffuse Down
- SW Global Down
- LW Down

Most Files:
- LW Up
- SW Up

Some Files:
- PAR (Surfrad)
- UVB (Surfrad)
- Active Cavity Direct (NREL, SSV)

Selected Files:
- **AERONET** Aerosol Optical Depth (ARM/CART) (LaRC/COVE) (NREL/SSV) (Surfrad/Bondville, IL)
- **SUNY ASRC MFRSR** Aerosol Optical Depth (CART Site)
- **CMDL MFRSR** Aerosol Optical Depth (Boulder, CO)

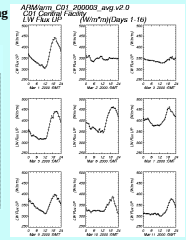
Most Files:
- Air Temperature
- Air Pressure
- Relative Humidity
- Wind Speed
- Wind Direction

Some Files:
- Precipitation

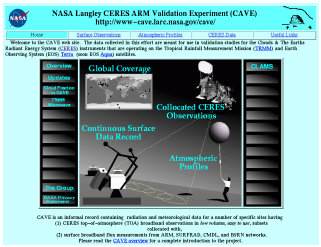
Surface, Aerosol & Meteorology (SAM) files:
- One month data per site
- 1/2 hour averages

Web tool to plot any available CAVE surface data.

Surface Data Plotting Capability

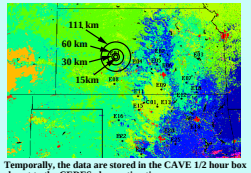


CAVE Home Page



CERES data file:
- One month of CERES fluxes per site

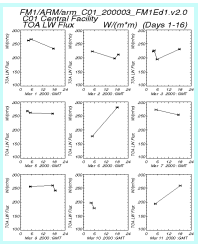
CERES ES8 Footprint data
- Subset within 111km of each surface site and given in 5 ways.
  - Closest Footprint
  - 4 Averages within concentric circles of increasing radii.



Temporally, the data are stored in the CAVE 1/2 hour box closest to the CERES observation time.

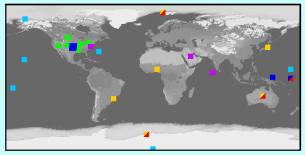
Web tool to plot any available CAVE CERES data.

CERES ES8 TOA Data Plot



Map of surface sites included in the CAVE.

CAVE Sites



ARM | CMDL
SURFRAD | NREL, Indoex, LaRC
BSRN | No Surface Data Yet

Temporal Coverage

CAVE covers CERES time period, 1998 onward.
- Time step in CAVE files is 1/2 hour.
- CAVE files contain 1 month of data.
- Surface files contain 1/2 hour averges of observations.
- CERES TOA files contain TOA values placed into 1/2 hour time 'box' nearest to observation time.

CAVE Surface Sites

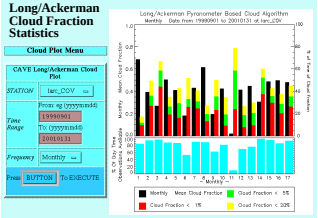
Project Name	No. Of Sites	Time Availability
ARM	23	Jan 1996 through May 2001
BSRN	6	Jan 1996 through Dec1998
CMDL	7	Jan-Aug 1998, Mar 2000 – May 2001
INDOEX	1	Feb, Mar 1999
LaRC/COVE	1	Sep 1999 through Aug 2001
NREL	1	Sep 1999 through Feb 2001
SURFRAD	6	Jan 1998 through Aug 2001

CAVE Sites With Colocated CERES Data

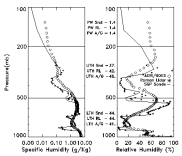
		Time Availability		
Project Name	No. Of Sites	TRMM FM	Terra FM1	Terra FM2
All Sites	46	Jan to Aug 1998	Mar 2000 to Apr 2001	Mar 2000 to Apr 2001

Cloud fraction as determined by the Long/Ackerman algorithm is available at a number of CAVE sites.

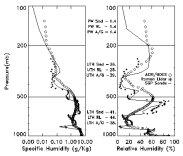
Long/Ackerman Cloud Fraction Statistics



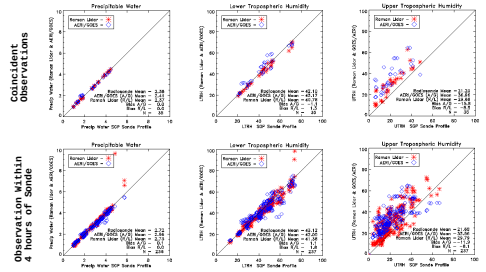
Sonde, R/L & A/G matched in time.



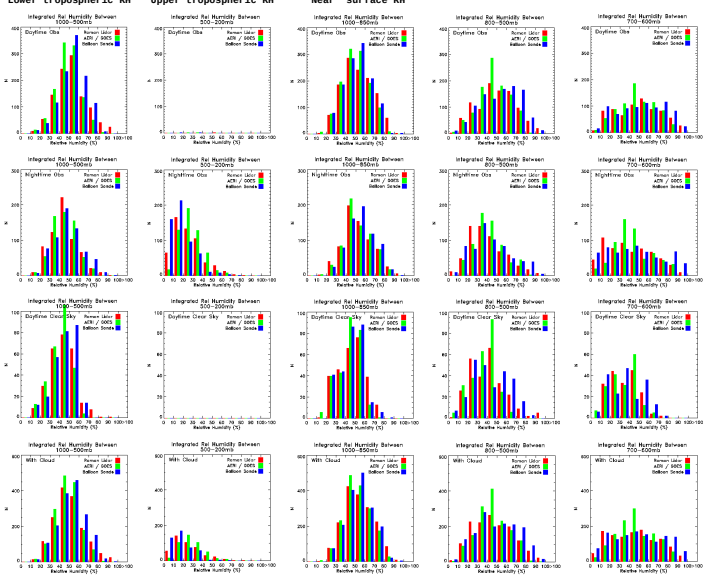
Interpolated profile 4 hours before balloon launch.



Selecting only those times where all three methods have a result during the 4 month period; these plots show a summary comparison of Precipitable Water, Lower Tropospheric RH (Sfc-500mb) and Upper Tropospheric RH (500-200mb).



One way to consider the variablity of the three water vapor retrieval methods is to integrate the relative humiditiy (RH) between various pressure levels under different meteorological conditions. Changes in the distributions of these RH's may indicate problems in retrieval methods while consistency can indicate an agreement of water vapor retrieved by the various methods. (In order for a point to be included in a distribution all three methods must return a result for that time period/condition. For example, since the R/L retrieves little data above 500mb during the day (though Sondes and A/G do) there are no points in the 500-200mb Daytime histogram.)



CAVE: On-line resource for high quality measurements of surface radiation collocated with neatly subset CERES TOA satellite data.

Corresponding Author Address: d.a.rutan@larc.nasa.gov
CAVE Home Page : http://www-cave.larc.nasa.gov/cave/